Mayer F[1], Arampatzis A[2], Banzer W[3], Beck H[4], Brüggemann G-P[5], Hasenbring M[6], Kellmann M[7], Kleinert J[8], Schiltenwolf M[9], Schmidt H[10], Schneider C[11], Stengel D[12], Wippert P-M[13], Platen P[14]

Medicine in Spine Exercise [MiSpEx] – a National Research Network to Evaluate Back Pain

Medicine in Spine Exercise [MiSpEx] – ein nationales Forschungsnetzwerk zur Evaluation von Rückenschmerzen

REVIEW

ACCEPTED: June 2018

PUBLISHED ONLINE: July 2018

DOI: 10.5960/dzsm.2018.340

Mayer F, Arampatzis A, Banzer W, Beck H, Brüggemann G-P, Hasenbring M, Kellmann M, Kleinert J, Schiltenwolf M, Schmidt H, Schneider C, Stengel D, Wippert P-M, Platen P. Medicine in Spine Exercise [MiSpEx] – a national research network to evaluate back pain. Dtsch Z Sportmed. 2018; 69: 229-235.

1. UNIVERSITÄT POTSDAM, *Zentrum für Sportmedizin, Potsdam*
2. HUMBOLDT-UNIVERSITÄT ZU BERLIN, *Training and Movement Sciences, Berlin*
3. GOETHE-UNIVERSITÄT FRANKFURT, *Abteilung Sportmedizin, Frankfurt*
4. UNIVERSITÄTSKLINIKUM CARL GUSTAV CARUS, *Centrum für Orthopädie & Unfallchirurgie, Dresden*
5. DEUTSCHE SPORTHOCHSCHULE KÖLN, *Institut für Biomechanik und Orthopädie, Köln*
6. RUHR-UNIVERSITÄT BOCHUM, *Medizinische Psychologie und Medizinische Soziologie, Bochum*
7. RUHR-UNIVERSITÄT BOCHUM, *Faculty of Sport Science, Sport Psychology, Bochum*
8. DEUTSCHE SPORTHOCHSCHULE KÖLN, *Institute of Psychology, Section Health & Social Psychology, Köln*
9. UNIVERSITÄTSKLINIKUM HEIDELBERG, *Klinik für Orthopädie und Unfallchirurgie, Heidelberg*
10. CHARITÉ-UNIVERSITÄTSMEDIZIN BERLIN, *Julius Wolff Institut, Berlin*
11. SCHÖN KLINIK MÜNCHEN HARLACHING, *Orthopädiezentrum Theresie, München*
12. UNFALLKRANKENHAUS BERLIN, *Zentrum für Klinische Forschung, Berlin*
13. UNIVERSITÄT POTSDAM, *Sport- und Gesundheitssoziologie, Potsdam*
14. RUHR-UNIVERSITÄT BOCHUM, *Sportmedizin und Sporternährung, Bochum*

Summary

- **Idiopathic as well as nonspecific low back pain** is relevant in health care systems as well as in leisure and high-performance sports. Neuromuscular and/or structural deficits, mostly accompanied by biopsychological factors, are known risk factors for both the onset and chronification of symptoms. Meta-analytic evidence describes positive effects of physical activity. However, type, dose-response relation, minimum of training required and setting-specific implementation has not been fully clarified.
- **Since 2011, the national research network** „Medicine in Spine Exercise" [MiSpEx] has been following a project layout called „Ran Rücken" focussing on the development and validation of intervention programs including neuromuscular and pain adaptation moderated by individual training status, pain behaviour, allostatic load and social settings. Overall about 8000 patients and athletes have been and are being followed experimentally and clinically in 34 studies.
- **It could be shown** that a training program focussing on compensation of external loads elicited by perturbations is effective in prevention and rehabilitation in both athletes and general population. Besides validation of further consecutively developed programs emphasis is put on the evaluation of transfer strategies to medical systems, sports as well as general population. Finally, the evaluation of an efficient dose-response relation is addressed.

KEY WORDS:
Low Back Pain, MiSpEx, Sports, Perturbations, Therapy, Prevention, Training

Zusammenfassung

- **Idiopathische und unspezifische Rückenschmerzen** sind relevant für das Gesundheitssystem sowie für Alltag, Breiten- und Spitzensport. Neuromuskuläre und strukturelle Defizite, häufig begleitet von biopsychosozialen Faktoren, sind ursächlich für den Beginn und die Chronifizierung der Symptome. Evident in Therapie und Prävention ist körperliche Aktivität, wobei nicht abschließend geklärt ist, welche Art und Dosierung effektiv ist, welches Trainingsminimum erreicht werden muss und wie unterschiedliche Adressatenkreise für einen nachhaltigen Effekt angesprochen werden müssen.
- **Das nationale Forschungsnetzwerk** „Medicine in Spine Exercise" [MiSpEx] arbeitet unter dem Projektnamen „Ran Rücken" seit 2011 an der Entwicklung und Validierung adressatengerechter Interventionsprogramme mit dem Ziel der Adaptation neuromuskulärer Interaktionen und Schmerz, moderiert durch Trainingszustand, Schmerzempfinden, allostatische Last und Versorgungskontext. Insgesamt wurden und werden rund 8000 Gesunde und Patienten mit Rückenschmerzen aus der Allgemeinbevölkerung und dem Spitzensport in 34 Projekten wissenschaftlich und klinisch betreut.
- **Es konnte nachgewiesen werden,** dass ein Training zur Kompensation externer Störreize (Perturbationen) bei geringem Aufwand präventiv und therapeutisch wirksam ist. Neben der Validierung neuer, konsekutiv auf den Ergebnissen aufgebauter Interventionsmodule, stehen die Evaluation von Transferstrategien in die medizinische Versorgung, die Systeme des Leistungssports und die Gesamtgesellschaft sowie die Analyse von Dosis-Wirkungsbeziehungen im Fokus des Projektes

SCHLÜSSELWÖRTER:
Rückenschmerzen, MiSpEx, Sport, Perturbationen, Therapie, Prävention, Training

Introduction

Idiopathic as well as nonspecific low back pain is relevant in health care systems as well as leisure and high-performance sports. Several studies described low back pain as one of the most common reasons to be absent from work, training and competition in high-performance sports. In the general population, lifetime prevalence is reported up to 90 % in western industrialized countries, point prevalence varies between 30 and 50%, depending on age and sex (1, 6, 13, 28). In athletes, an extremely high variability for lifetime prevalence of 1-94% (point prevalence 18-65%) depending on discipline and type of sports is described (25, 26). Furthermore, available database is inconclusive and restricted by various definitions and inclusion criteria used in the different publications. ›

CORRESPONDING ADDRESS:
Prof. Dr. Frank Mayer
University of Potsdam, University Outpatient Clinic, Center of Sports Medicine
Am Neuen Palais 10, Haus 12
14469 Potsdam
✉: fmayer@uni-potsdam.de

Table 1

Multicenter and center based studies (MiSpEx network) within "Ran Rücken".

MULTICENTER STUDIES	
ZSA	Validity of Outcome variables
MSB	Feasibility of piloted exercise interventions
MCSB	Prove of effectiveness of exercise interventions in low back pain
Transfer	Development of a transfer concept for exercise interventions
CENTER-BASED STUDIES (PARALLEL STUDIES)	
PSA_1	Neuromuscular control during perturbations
PSA_2	Evaluation of trunk stability
PSA_3	Stress-related markers in pain prevention
PSA_4	Evaluation of trunk movements
PSA_5	Mathematic modelling: muscle forces and trunk load
PSA_6	Neuromuscular control of trunk stability
PSA_7	Movement variability in pain patients
PSA_8	Strength performance capacity and core stability
PSA_9	Trunk adaptations to training
PSA_{10}	Systematic analysis of core posture and movements in different types of sports
PSA_{11}	Quantitative analyses of mechanical trunk load in different types of sports
PSA_{12}	Biopsychosocial risk factors and mechanisms in low back pain
PSA_{13}	Effectiveness of risk-factor-based cognitive treatment
PSA_{14}	Optimization of volitional behavior in rehabilitation
PSA_{15}	Quantitative sensory testing of pain
PSA_{16}	Central adaptations to training
PSB_1	Development and validation of sports-type- and load-related exercises
PSB_2	Psychosocial competences and factors in the treatment and prevention of low back pain
PSB_3	Development and evaluation of therapeutic and preventive, addressee-related intervention programs in athletes and the overall population
PSB_4	Intra-individual, longitudinal analysis of exercise interventions
PSC_1	Transfer of diagnostic markers to clinical and field settings
PSC_2	Valid and reliable measurements of postural control in a field setting
PSC_4	Psychosocial competences in back pain prevention and therapy: Transfer of social related approaches in high-performance sports and overall population
PSC_5	Sustainability of (piloted) exercise interventions
PSD_1	Cumulative strain and fatigue on trunk load. Load atlas of the trunk in daily life and sports
PSD_3	Relation of artificial pain inhibition and neuromuscular performance in LBP patients
PSD_7	Minimum dose-response relation in perturbation-based exercise interventions
PSD_8	How much is enough? Dose-response relation of sensory motor training in low back pain
PSD_9	Therapy frequency and compliance to predict low back pain relapse
PSD_{10}	Dose-response-relation of behavioral modules on pain perception and processing

Most papers point out that symptoms (mainly pain) and imaging of structural alterations do no correlate as often assumed in clinical practise (13, 17). This is particularly evident when symptoms aggravate over time and finally chronify. Consequently, neuromuscular as well as structural deficits, mostly accompanied by biopsychological factors are known risk factors for both the onset and chronification of symptoms (2, 4, 7, 9, 10, 11, 22, 24, 27). To date there are no finally proven concepts and mechanisms if and how muscle strength as well as neuromuscular control of trunk stability might help to compensate external load leading to (low) back pain symptoms in athletes as well as the general population. However, several approaches have been published emphasizing that immediate compensation of unexpected external loads is altered in low back pain patients and therefore might be discussed as valid therapy approach as well as preventive strategy (3, 7, 8, 21).

Meta-analytic evidence describes positive effects of physical activity in the treatment and the prevention of low back pain (1, 5, 6, 13, 28). Mainly in population-based analysis it could be shown that exercise is superior to other treatments in (chronic) LBP patients (13, 22, 28). Evidence-based approaches are recently multimodal and individualized including physical activity as one main column of concept (1, 5, 13, 22, 24, 27, 28). However, type of exercise, dose-response relationship, minimum of training required as well as setting-specific implementation of therapeutic treatments to optimise training effects and minimise the amount of non-responders is not finally clarified. A most recent Cochrane review has shown that so-called motor control exercises might be beneficial (22). However, due to widely varying definitions of the exercises used and diverging outcome variables effects were described low and inconsistent. It is additionally discussed that the impact based on neuromuscular coordination including measurements of muscle strength, kinetics, kinematics, muscular activity and postural control is still lacking. Nevertheless, the ability of the neuromuscular system to compensate and counteract control errors introduced from deficits in the perception of the spine state and conversion of this information into appropriate motor commands as well as the ability to regain spine stability after unexpected load-induced perturbations by an appropriate neuromuscular control are important components for avoiding low-back pain (3, 6, 7, 8, 18, 21).

Unfortunately, in these concerns the published data including clinically-evident cross-sectional and longitudinal preventive and therapeutic approaches especially in high-performance athletes are rare, even if individualized training, neuromuscular programs as well as sophisticated dose-response scheduling is professionally implemented in daily practice.

Based on the background mentioned, in 2011, a national research network called "Medicine in Spine Exercise [MiSpEx]" was founded, focussing on the development and the validation of preventive and therapeutic (exercise) interventions in non-specific low back pain patients from both general public and athletes. In a granted program from German "Bundesinstitut für Sportwissenschaft" named "Ran Rücken" basic intervention effects were validated and related to diagnostic algorhythms. Further focus was placed on the definition of a minimum and individualized response (adaptation) threshold as well as the dose-response relation in athletes and non-athletes. Additionally, basic-science and experimental results were implemented in clinical studies and finally transferred in the populations addressed.

Figure 1

Recent members and locations of the research network "Medicine in Spine Exercise (MiSpEx).

Reasearch Questions and Scientific Approach

Chronic low-back pain patients where a recognizable, specific pathology is lacking, are diagnosed as "non-specific". Repetitive and high external loads in high-performance sports, occupation as well as daily life and leisure activities are assumed to be reasons for non-specific low back pain (1, 17, 24, 26, 28). Therefore, the compensation of these external loads in definite situations is mandatory. However, individual neuromuscular deficits might restrict the compensation capacity, consequently predispose to overload and therefore elicit low back pain. The origin of pain, however, in most of the cases is not clear. Microtrauma and muscle-tendon insufficiencies in combination with muscle strain and ligament strain are discussed as valid reasons for pain development (1, 13, 17, 27). In case of suddenly increase in load intensity (single overload mainly due to unexpected load; repetitive high as well as unexpected loads) tolerance limits might be exceeded if compensation is too slow or insufficient. As a consequence intervention strategies should emphasize the implementation of exercises, aiming on compensation of external loads in specific situations (sports, daily life, and occupation).

Within the research network both an evidence-based concept and useful exercises have to be developed and validated that rationally show adaptation in pain perception as well as in muscle strength and neuromuscular control of spine stability. Dosing of exercises and programs has to incorporate high and unexpected loads. Since high compliance and adherence in combination with time- and cost-saving approaches is intended a minimum threshold of training effects needs also to be defined for both high-performance sports as well as the overall population. Above this threshold the course of dose-response relation should be evaluated.

Further emphasis has to be on diagnostic procedures to both develop and individually assign valid exercises aiming on low back pain risk reduction and adaptation of pain as well as neuromuscular capacities. In addition theses diagnostic variables should reliably evaluate and predict the intervention outcome. Main target criteria therefore have to be defined in pain perception as well as neuromuscular adaptation due to individualized exercises based on unexpected and high loads. Furthermore, it has to be analyzed if there are confounding variables moderating the intervention effect (11, 12, 14, 15, 20, 23). Firstly, since well proven, effects have to be discussed in dependence on individual training status, mainly parametrized in neuromuscular capacities. In addition, it is very well known, that biopsychosocial factors like pain behavior, allostatic load, motivation as well as social environments might influence the perception of low back pain and therefore potentially will influence the effectiveness of (exercise) interventions in athletes and non-athletes.

Besides validation of further consecutively developed programs emphasis has to be put on the evaluation of transfer strategies with respect to addressee-dependent dose-response-relation in medical systems, sports as well as overall population.

In summary, the following main research questions were set for the "Ran Rücken" project, realized by MiSpEx network:

F1: Which (exercise) interventions (intervention programs) based on an optimization of neuromuscular control lead to a valid and reliable reduction of low back pain symptoms in patients and to risk reduction in healthy subjects?

F2: Which isolated variables (sets of variables) can be defined to deduce valid exercise interventions and to measure the longitudinal effect of exercise interventions to reduce symptoms as well as the risk of low back pain in athletes and the general population? ›

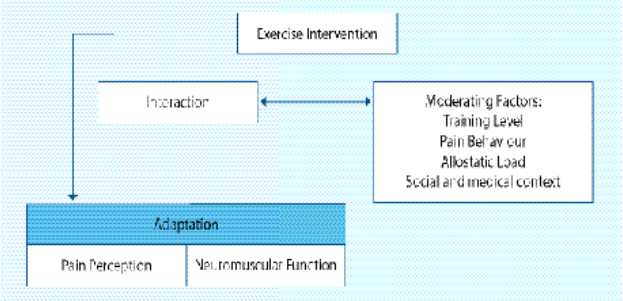

Figure 2

Research paradigm of "Ran Rücken" realized by the national research network „Medicine in Spine Exercise, (MiSpEx)". Outcome variables and moderating factors for the development, validation and transfer of exercise interventions in prevention and rehabilitation of low back pain in both athletes as well as the general population.

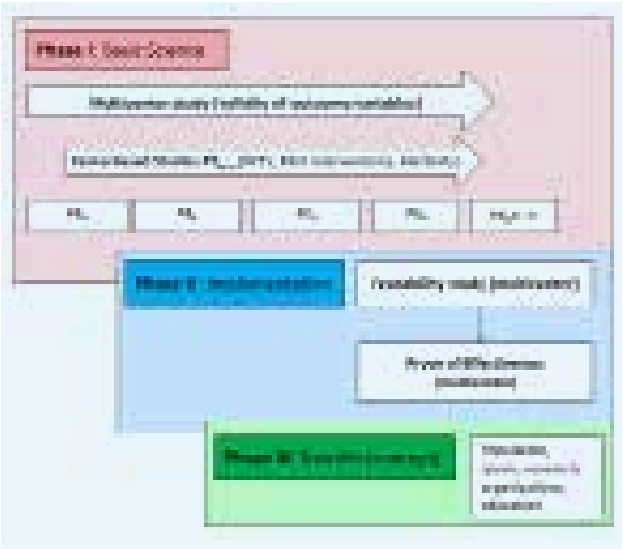

Figure 3

Study flow chart. Multicenter and center based parallel studies, separated in three overall project phases [basic science, implementation, transfer].

F3: Is there any moderating influence of the individual training status regarding neuromuscular control as well as biopsychosocial factors on the effectiveness of (exercise) interventions?

F4: Which transfer strategies aiming on adherence and compliance to implement exercise interventions are advisable for high-performance sports and the general population?

Methods and Organization

Ran Rücken and MiSpEx exist since 2011 implementing university departments, scientific institutions as well as clinical departments that allow admission to patients and athletes with low back pain in daily clinical care and guarantee scientific knowledge and approaches to experimental as well as clinical studies in a translational way (Fig. 1). According to the research questions raised a research paradigm was developed taking pain and neuromuscular adaptation to exercise interventions moderated by training status and biopsychological factors into account (Fig. 2). With respect to the translational development of experimental data through clinical implementation to transfer concepts the research schedule consists of three phases overlapping each other (Fig. 3). To date about 8.000 patients and athletes have been and are followed experimentally and clinically in 34 studies (Table 1).

Within the first phase (basic-science) the research paradigm was validated. Therefore, center-based studies working on isolated questions regarding pain perception and behavior, neuromuscular adaptation, moderating biopsychosocial factors, type of exercises, effect of unexpected loads and dose-response relation were realized (Table 1). Additionally, two multi-center studies took place (Table 1, Fig. 3). In a first approach validity of possible outcome criteria (pain behaviour: e.g. v. Korff grades, visual analogue scales; neuromuscular: e.g. back extension and flexion strength, postural stability during one-leg stance, jumping variables) were analyzed in a sample of athletes and subjects from general population with and without pain (n=1072) in a longitudinal design over 2 years (28). Additionally, feasibility of piloted exercises was analyzed in a prospective multicenter study (n=744, 4 exercises per session, 12 difficulty levels, 3 weeks center-based, 9 weeks home-based, 6 months-sustainability). In the second phase implementation of results of basic science and initial multicenter studies flow into the central prove of effectiveness. This GCP-study is recently ongoing involving n=1580 subjects in a two-group design (intervention vs. control) with a follow up of one year (19). This study is assisted by another group of center-based studies working on detailed but still open queries. In the third phase, finally, all results consequently are implemented in a transfer strategy dedicated to different settings like Olympic medical centers, outpatient clinics, rehabilitation centers as well as sports organizations, research and education.

Results

"MiSpEx" and "Ran Rücken" are running till the end of 2018. Consequently final results are recently not available. However, isolated results have already been published (or will be published in this supplement), which should be stated briefly (3, 8, 14, 15, 16, 18, 26, 29). Basic analysis showed a high variability of low back pain prevalence in athletes (25), an increasing load towards caudal segments elicited mainly by rotation, reclination and translation as well as valid outcome variables for pain perception and neuromuscular control as mentioned before (3, 8, 14, 15, 18, 29). It could be shown that perturbation-based implementation of external loads to the human body will lead to neuromuscular adaptation (3, 8, 18). Furthermore, compensation of external loads elicited by perturbations as well as combined perturbation-based sensory motor or strength training are effective in prevention and rehabilitation (multicentre pilot results).

There is evidence that compliance and adherence is strongly related to intrinsic motivation as well as individualized patients behaviour in some patients groups. Therefore, it is desirable to screen individuals (high-performance athletes as well as general population) before accessing the training program mentioned above. Here, a strategy for individualized screening will be recommended. Considering transfer the recent state shows that strategies differ between addressees. Within high-performance sports mainly concepts and strategies with its implementation in daily training procedures, rather than isolated exercises, can be delivered. In the general population exercise intervention programs are welcome including dosing as well as algorhythms to individualize, control and evaluate. The chosen strategy of 3 weeks center-based education, followed by a controlled 9 week home-based phase seems to be appropriate.

In conclusion, it recently can be stated that exercise interventions based on perturbations are effective in prevention and rehabilitation of low back pain in high-performance sports as well as the general population. Individualization as well as consideration of training status and biopsychosocial moderators is mandatory. Pre-training screening therefore is likely to be beneficial. In diagnostics as well as longitudinal follow-up evaluation variables out of pain perception and neuromuscular control are valid tools to choose compilation of exercises and to rate effectiveness prospectively. Further and conclusive results will be available at the end of the project presented.

Acknowledgements

Heads of Additional Study Centers

A. Barié (Heidelberg), R. Brand (Potsdam), K. Dreinhöfer (Berlin), G. Duda (Berlin), P. Kasten (Dresden), C. Kirschbaum (Dresden), T. M. Pippig (Luftwaffe), A. Rohlmann (Berlin), H. Schmitt (Heidelberg), N. Streich (Heidelberg), L. Vogt (Frankfurt)

Scientists in Study Centers

- María Moreno Catalá, Ralf Dietrich, Lisa Diepgen, Arno Schroll, Gunnar Laube, Willi Rinke (Humboldt-Universität zu Berlin, Department of Training and Movement Sciences)
- Jeronimo Weerts, Esther Pries, Rizwan Arshad (Julius Wolff Institut, Charité-Universitätsmedizin Berlin)
- Michael Schäfer, Sabine Schüler (Medical Park Berlin Humboldtmühle, Abt. für muskuloskeletale Rehabilitation, Prävention und Versorgungsforschung, Charité-Universitätsmedizin Berlin)
- Tobias Engeroff, Johannes Fleckenstein, Florian Giesche, Meltem Hacibayramoglu, Kristin Kalo, Frieder Krause, Daniel Niederer, Andreas Rosenhagen, Johanna Vogel, Jan Wilke (Goethe-Universität Frankfurt, Abteilung Sportmedizin)
- Jahan Heidari, Tobias Mierswa (Faculty of Sport Science, Unit of Sport Psychology, Ruhr-Universität Bochum)
- Claudia Levenig (Medizinische Psychologie und Medizinische Soziologie, Ruhr-Universität Bochum)
- Markus De Marées, Daniela Fett, Katharina Trompeter, Robin Schäfer, Jan Venzke (Lehr- und Forschungsbereich Sportmedizin und Sporternährung, Fakultät für Sportwissenschaft, Ruhr-Universität Bochum)
- Kai Heinrich, Institut für Biomechanik und Orthopädie, Deutsche Sporthochschule Köln
- Johanna Belz, Angeli Gawlik (Institute of Psychology, Section Health & Social Psychology, German Sport University Cologne)
- Ernst Riewe, Barbara Pader, Eva Neubauer, Thomas Gwechenberger (Universitätsklinikum Heidelberg, Klinik für Orthopädie und Unfallchirurgie, Zentrum für Orthopädie, Unfallchirurgie und Paraplegiologie)
- Jan Jens Kolterman, Philipp Flößel (Universitätsklinikum Carl Gustav Carus, Universitäts Centrum für Orthopädie & Unfallchirurgie)
- Thore-Björn Haag (SCHÖN Klinik München Harlaching Sportorthopädisches Institut & Orthopädiezentrum Theresie München), Martin Handel, Imme Korthals (SCHÖN Klinik München Harlaching Sportorthopädisches Institut)
- Jasmin Honold, Jessie de Witt Huberts, Anne-Kathrin Puschmann, Christine Wiebking, Kathrin Klipker, Caroline Holzer, Michael Fliesser, Anja Weiffen, Christiano Cellini, Martin Horack (Universität Potsdam, Sport- und Gesundheitssoziologie)
- Adina Eggert, Tilman Engel, Katja Frölich, Dina Intziegianni, Hannes Kaplick, Stefan Kopinski, Jessica Messerschmidt, Juliane Müller, Steffen Müller, Judith Reso, Daniela Schubert, Josefine Stoll (Hochschulambulanz der Universität Potsdam, Zentrum für Sportmedizin)
- Franziska Antoniewicz (Universität Potsdam, Sportpsychologie)
- Claas Güthoff, Alexander Hönning (Zentrum für Klinische Forschung Unfallkrankenhaus Berlin)

Cooperation Partners

- AOK Nordwest (Westfalen, Lippe, Schleswig-Holstein)
- Berliner Ruder Club
- Brandenburgische Technische Universität Cottbus-Senftenberg
- Bundesministerium des Innern
- Bundeswehr, Zentrum für Luft- und Raumfahrtmedizin der Luftwaffe
- Charite Universitätsmedizin Berlin, Centrum für Muskuloskeletale Chirurgie (CMSC), Wirbelsäulentherapie, Sportmedizin
- Deutscher Hockey Bund e.V. (DHB)
- Deutscher Kanu-Verband (DKV)
- Deutscher Olympischer Sportbund (DOSB)
- Deutscher Ruder Verband-Ruderleistungszentrum Dortmund
- Eliteschulen Sport des Landes Brandenburg
- Gemeinschaftspraxis Chiropädicum, Berlin
- Heilpraxis für Osteopathie & Physiotherapie Hübner & Werner, Berlin
- Hochschule für Gesundheit, Bochum
- Hochschulsport der Ruhr-Universität Bochum (RUB)
- Klinikum Ernst von Bergmann (Anästhesiologie) gGmbH, Potsdam
- Medical Park Berlin Humboldtmühle, Berlin
- medicos.AufSchalke, Gelsenkirchen
- Medizinische Klinik für Rheumatologie, Berlin
- Ministerium des Innern (MIK) des Landes Brandenburg
- Ministerium für Bildung, Jugend und Sport des Landes Brandenburg
- NOVOTERGUM AG, Essen
- OGP Orthopädische Gemeinschaftspraxis
- Oer-Erkenschwick
- Olympiastützpunkte Berlin, Brandenburg, Rhein-Neckar
- Polizei Nordrhein-Westfalen
- Rehazentrum am Virchowklinikum, Berlin
- Rugby Klub 03 Berlin e.V.
- SLZ-Berlin, Eliteschule des Sports
- SMZ Physiotherapie Bochum GmbH
- Sportschule im Olympiapark – Poelschau-Schule, Berlin
- SV Babelsberg (Fußball)
- Trainerakademie des DOSB, Köln
- TuS Lichterfelde Hockey e.V.
- Universitätsklinik Bochum (Anästhesiologie, Intensiv-, Palliativ- und Schmerzmedizin)
- VC Olympia Berlin e.V.
- Werderaner FC Viktoria 1920 (Fußball), Potsdam

Förderung

Das MiSpEx-Netzwerk wird gefördert aus Mitteln des Bundesinstituts für Sportwissenschaft (BiSp) aufgrund eines Beschlusses des Deutschen Bundestages [Förderkennzeichen ZMVI1-080102A/11-18].

References

(1) **AIRAKSINEN O, BROX JI, CEDRASCHI C, HILDEBRANDT J, KLABER-MOFFETT J, KOVACS F, MANNION AF, REIS S, STAAL JB, URSIN H, ZANOLI G.** Chapter 4. European guidelines for the management of chronic nonspecific low back pain. Eur Spine J. 2006; 15: s192-s300. doi:10.1007/s00586-006-1072-1

(2) **ANDERSSON E, SWÄRD L, THORSTENSSON A.** Trunk muscle strength in athletes. Med Sci Sports Exerc. 1988; 20: 587-593. doi:10.1249/00005768-198812000-00012

(3) **ARAMPATZIS A, SCHROLL A, CATALÁ MM, LAUBE G, SCHÜLER S, DREINHOFER K.** A random-perturbation therapy in chronic non-specific low-back pain patients: a randomised controlled trial. Eur J Appl Physiol. 2017; 117: 2547-2560. doi:10.1007/s00421-017-3742-6

(4) **BORGHUIS J, HOF AL, LEMMINK PM.** The importance of sensory-motor control in providing core stability: implications for measurement and training. Sports Med. 2008; 38: 893-916. doi:10.2165/00007256-200838110-00002

(5) **BURTON AK, BALAGUÉ F, CARDON G, ERIKSEN HR, HENROTIN Y, LAHAD A, LECLERC A, MÜLLER G, VAN DER BEEK AJ.** Chapter 2. European guidelines for prevention in low back pain. Eur Spine J. 2006; 15: s136-s168. doi:10.1007/s00586-006-1070-3

(6) **CHOI BK, VERBEEK JH, TAM WW, JIANG JY.** Exercises for prevention of recurrences of low-back pain. Cochrane Database Syst Rev. 2010; 1: CD006555. doi:10.1002/14651858.CD006555

(7) **CHOLEWICKI J, SILFIES SP, SHAH RA, GREENE HS, REEVES NP, ALVI K, GOLDBERG B.** Delayed trunk muscle reflex responses increase the risk of low back injuries. Spine. 2005; 30: 2614-2620. doi:10.1097/01.brs.0000188273.27463.bc

(8) **ENGEL T, MUELLER J, KOPINSKI S, RESCHKE A, MUELLER S, MAYER F.** Unexpected walking perturbations: Reliability and validity of a new treadmill protocol to provoke muscular reflex activities at lower extremities and the trunk. J Biomech. doi:10.1016/j.jbiomech.2017.02.026

(9) **FERSUM KV, DANKAERTS W, O'SULLIVAN PB, MAES J, SKOUEN JS, BJORDAL JM, KVÅLE A.** Integration of subclassification strategies in randomised controlled clinical trials evaluating manual therapy treatment and exercise therapy for non-specific chronic low back pain: a systematic review. Br J Sports Med. 2010; 44: 1054-1062. doi:10.1136/bjsm.2009.063289

(10) **HARTVIGSEN J, LINGS S, LEBOEUF-YDE C, BAKKETEIG L.** Psychosocial factors at work in relation to low back pain and consequences of low back pain: A systematic, critical review of prospective cohort studies. Occup Environ Med. 2004; 61: e2.

(11) **HASENBRING M, VERBUNT JA.** Fear-Avoidance and endurance-related responses to pain: New models of behaviour and their consequences for clinical practice. Clin J Pain. 2010; 26: 747-753. doi:10.1097/AJP.0b013e3181e104f2

(12) **HASENBRING MI, CHEHADI O, TITZE C, KREDDIG N.** Fear and anxiety in the transition from acute to chronic pain: There is evidence for endurance besides avoidance. Pain Manag. 2014; 4: 363-374. doi:10.2217/pmt.14.36

(13) **HAYDEN JA, VAN TULDER MW, MALMIVAARA A, KOES BW.** Exercise therapy for treatment of non-specific low back pain. Cochrane Database Syst Rev. 2005; 3: CD000335.

(14) **HEIDARI J, HASENBRING M, KLEINERT J, KELLMANN M.** Stress-related psychological factors for back pain among athletes: Important topic with scarce evidence. Eur J Sport Sci. 2017; 17: 351-359. doi:10.1080/17461391.2016.1252429

(15) **KLEINERT J, OTT I, MIERSWA T, LEVENIG CG, WENGE K, HASENBRING M, KELLMANN M.** Exercise motivation and non-specific back pain: A comparison of patients and non-patients. Rehabil Psychol. 2017; 62. doi:10.1037/rep0000149

(16) **KOLTERMANN JJ, GERBER M, BECK H, BECK M.** Validation of the HUMAC Balance System in Comparison with Conventional Force Plates. Technologies. 2017; 5: 44. doi:10.3390/technologies5030044

(17) **MALLIAROPOULOS N, BIKOS G, MEKE M, TSIFOUNTOUDIS I, PYNE D, KORAKAKIS V.** Mechanical Low Back Pain in Elite Track and Field Athletes: An observational cohort study. J Back Musculoskeletal Rehabil. 2017; 30: 681-689. doi:10.3233/BMR-150390

(18) **MUELLER J, ENGEL T, MUELLER S, STOLL J, BAUR H, MAYER F.** Effects of sudden walking perturbations on neuromuscular reflex activity and three-dimensional motion of the trunk in healthy controls and back pain symptomatic subjects. PLoS One. 2017; 12: e0174034. doi:10.1371/journal.pone.0174034

(19) **NIEDERER D, VOGT L, WIPPERT P-M, PUSCHMANN A-K, PFEIFER A-C, SCHILTENWOLF M, BANZER W, MAYER F.** Medicine in spine exercise (MiSpEx) for nonspecific low back pain patients: study protocol for a multicentre, single-blind randomized controlled trial. Trials. 2016; 17: 507. doi:10.1186/s13063-016-1645-1

(20) **PFEIFER AC, EHRENTHAL JC, NEUBAUER E, GERIGK C, SCHILTENWOLF M.** Impact of attachment behavior on chronic and somatoform pain. Schmerz. 2016; 30: 444-456. doi:10.1007/s00482-016-0156-z

(21) **RADEBOLD A, CHOLEWICKI J, PANJABI MM, PATEL TC.** Muscle response pattern to sudden trunk loading in healthy individuals and in patients with chronic low back pain. Spine. 2000; 25: 947-954. doi:10.1097/00007632-200004150-00009

(22) **SARAGIOTTO BT, MAHER CG, YAMATO TP, LO TP C, MENEZES COSTA L, OSTELO R, MACEDO L.** Motor control exercise for chronic non-specific low-back pain. Cochrane Database Syst Rev. 2016; CD012004.

(23) **SCHILTENWOLF M, AKBAR M, NEUBAUER E, GANTZ S, FLOR H, HUG A, WANG H.** The cognitive impact of chronic low back pain: Positive effect of multidisciplinary pain therapy. Scand J Pain. 2017; 17: 273-278. doi:10.1016/j.sjpain.2017.07.019

(24) **SCHROEDER J, OTTE A, REER R, BRAUMANN KM.** Low Back Pain – an Umbrella Overview of Exercise Therapy in the General Population and Special Demands in Athletes. Dtsch Z Sportmed. 2015; 66: 257-262. doi:10.5960/dzsm.2015.191

(25) **SCHULZ SS, LENZ K, BUETTNER-JANZ K.** Severe back pain in elite athletes: a cross-sectional study on 929 top athletes of Germany. Eur Spine J. 2016; 25: 1204-1210. doi:10.1007/s00586-015-4210-9

(26) **TROMPETER K, FETT D, PLATEN P.** Prevalence of back pain in sports: a systematic review of the literature. Sports Med. 2016; 46: 1-25. doi:10.1007/s40279-016-0645-3

(27) **VAN MIDDELKOOP M, RUBINSTEIN SM, KUIJPERS T, VERHAGEN AP, OSTELO R, KOES BW, VAN TULDER MW.** A systematic review on the effectiveness of physical and rehabilitation interventions for chronic non-specific low back pain. Eur Spine J. 2011; 20: 19-39. doi:10.1007/s00586-010-1518-3

(28) **VAN TULDER MW, BECKER A, BEKKERING T, BREEN A, DEL REAL MTG, HUTCHINSON A, KOES BW, LAERUM E, MALMIVAARA A.** Chapter 3. European guidelines for the management of acute nonspecific low back pain in primary care. Eur Spine J. 2006; 15: s169-s191. doi:10.1007/s00586-006-1071-2

(29) **WIPPERT P-M, PUSCHMANN A-K, DRIESSLEIN D, ARAMPATZIS A, BANZER W, BECK H, SCHILTENWOLF M, SCHMIDT H, SCHNEIDER C, MAYER F.** Development of a risk stratification and prevention index for stratified care in chronic low back pain. Focus. PAIN Reports. 2017; 1. doi:10.1097/PR9.0000000000000623